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PATENT SPECIFICATION

(11) 1 441 919

(21) Application No. 35026/72 (22) Filed 26 July 1972
(23) Complete Specification filed 26 July 1973
(44) Complete Specification published 7 July 1976
(51) INT CL² B32B 31/20, 5/28
(52) Index at acceptance B5N 0526 0528 0900 2704 2738 3120
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(19)

(54) IMPROVEMENTS IN OR RELATING TO THE PRODUCTION OF FIBRE-REINFORCED SYNTHETIC RESIN ARTICLES

(71) We, HAWKER SIDDELEY AVIATION LIMITED, a British Company, of Richmond Road, Kingston-Upon-Thames, Surrey, KT2 5QS., do hereby declare the invention for which we pray that a Patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to the production of fibre-reinforced synthetic resin articles and more especially, but not exclusively, carbon-fibre-reinforced resin laminates.

Our Patent Specification No. 1,305,556 describes a technique developed for consolidating carbon-fibre-reinforced resin laminates by the absorption of surplus resin and layers of bleeder material while the laminate is subjected to an external pressure. A feature of this technique is that the consolidation pressure is applied to the laminate/bleeder assembly as a whole so that as long as the resin is mobile and there is bleeder material into which it can flow, there is no hydrostatic pressure applied to the resin. In such circumstances, the consolidating pressure causes compaction of the fibres.

Certain resin compositions, notably the much favoured epoxy resin formulae, are so compounded that a significant amount of volatile matter is given off at the normal curing temperature and it has been shown that this outgassing leads to voids, both micro and macro, in the finished laminate and hence to poor mechanical properties, particularly in regard to interlaminar shear strength. The only method that has so far been used to deal effectly with outgassing is generally as follows.

a) Preheat the laminate for a predetermined period of time at a temperature below that at which rapid gelation will occur, with or without over-pressure, but with the laminate vented to atmosphere or to a low vacuum (typically 2/4 ins. Hg).

b) Raise the temperature and then apply a consolidating pressure at a predetermined instant during gelation with the laminate still vented as previously.

This type of cure cycle has been found to minimise laminate void content. However, it requires precise knowledge of the resin state throughout the early stages if it is to be effective and no reliable means of obtaining this knowledge under practical manufacturing conditions has yet become available. The present invention therefore seeks to achieve a better technique.

According to the invention, there is provided a process for the production of a fibre-reinforced synthetic resin laminate wherein the laminate is cured under consolidating pressure that is supplied to the exterior of a deformable chamber in which the laminate is sealed, the interior chamber having applied to it a fluid pressure less than the external pressure but higher than the vapour pressure of the resin to prevent outgassing of the laminate.

Preferably, the laminate is covered by a flexible envelope or membrane and fluid pressure is applied within the membrane while a higher overall pressure is applied at the outside. The principle of this process is that the pressure under the membrane acts hydrostatically on the resin in the composite laminate and, being in excess of the vapour pressure, prevents the volatiles from boiling off during the curing cycle. If desired, step (a) of the prior process described above can still be incorporated into the cure cycle to reduce the base volatile level.

One arrangement for carrying the invention into effect is illustrated diagrammatically, by way of example, in the accompanying drawing, which is a cross section through a laminate undergoing curing.

A fibre-reinforced resin laminate 11 is consolidated and cured between two bleeder material layers 12, with a pervious release layer 13 between each bleeder layer and the laminate, so that the bleeder layers

soak up expelled excess resin as described in out Patent Specification No. 1,305,556. The whole layer assembly is covered by a flexible membrane 14 within which a hydrostatic pressure, typically 60lb/in², is applied to the resin by a gas or liquid via a membrane inlet 15.

Externally of the membrane 14, a higher overall pressure, typically 80lb/in², is applied in a direction substantially normal to the general plane of the laminate. This overall pressure can be generated mechanically by a press, or in an autoclave. In the example illustrated, the laminate and bleeder layer assembly is placed in a press, the covering membrane 14 being sealed down all round to the lower press platen 16, as at 17, to contain the hydrostatic pressure.

Thus, during curing the hydrostatic pressure of, say, 60lb/in² within the membrane prevents creation of any voids by boiling resin volatiles. And, at the same time, a consolidating pressure is applied to compact the fibres and expel excess resin into the bleeder skins.

The advantages are:

(1) Voids due to the boiling off of resin volatiles are eliminated.

(2) It is no longer necessary to monitor gelation of the resin.

(3) Relaxation of control on maximum resin volatile content is permissible.

WHAT WE CLAIM IS:

1. A process for the production of a fibre-reinforced synthetic resin laminate, wherein the laminate is cured under consolidating pressure that is applied to the exterior of a deformable chamber in which the laminate is sealed, the interior of the chamber having applied to it a fluid pressure less than the external pressure but higher than the vapour pressure of the resin to prevent outgassing of the laminate.

2. A process according to Claim 1, wherein the deformable chamber is formed by a flexible envelope or membrane enclosing the laminate, the fluid pressure being applied within the envelope while consolidating pressure is applied at the outside.

3. A process according to Claim 2, wherein the outside pressure is applied mechanically by a press.

4. A process according to Claim 2, wherein the outside pressure is applied in an autoclave.

5. A process according to any one of the preceding Claims, wherein the laminate is cured between two bleeder material layers that soak up expelled excess resin.

6. A process for the production of fibre-reinforced synthetic resin laminates, substantially as described with reference to the accompanying drawing.

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Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1976.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

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1 SHEET This drawing is a reproduction of the Original on a reduced scale